The call for integrating academic content into career and technical education (CTE) is getting stronger. As this academic emphasis increases, many CTE programs are now able to offer credit in math as part of their integrated academics programs. Frequently, the academic content is already available. Emphasizing it and making it documentable will often require collaboration between CTE and academic instructors.

CTE administrators can do a great deal toward fostering these partnerships between academic and CTE teachers by getting their staff together with academic instructors at a high school or having a math teacher meet with CTE staff during an in-service training day or professional development day at their career center. However, many career centers are hiring academic instructors as part of their staff. Sometimes, separate academic courses are developed where students may get assignments online and meet with academic teachers individually or in small groups to answer questions about assignments and take tests. In other cases, the academic teacher becomes part of each CTE program. They work with CTE teachers toward the goal of academic integration, they often observe the academics and projects already being done in the CTE program, and they may co-teach some lessons to emphasize and expand certain academic content within the CTE program. As this co-teaching process continues long term, cross-curricular projects can become a normal part of the program of study.

This article presents information about the Common Core State Standards (CCSS) for Mathematics for CTE instructors who must integrate these standards without a math expert on staff; we will gain insight on how high school math teachers may be challenged by the CCSS, which might draw them into partnering with CTE; and, finally, I will present some opportunities for an on-staff math instructor to get involved in CTE classrooms.

Accessing the CCSS

The broad goal of the Common Core State Standards Initiative is for students to graduate prepared to "succeed in college, career and life."[1] The standards are broken into two parts: practice and content. There are eight Standards for Mathematical Practice (Figure 1)—found in the "Common Core State Standards for Mathematics"[2]—which are to be developed across all grades. These standards are fairly accessible and come with a paragraph of explanation, and connections can readily be made to a CTE program. For example, the paragraph of explanation for Practice Standard 4 (Model with mathematics) suggests the "use [of] geometry to solve a design problem"[3] which often fits well in a construction or computer-aided design (CAD) class.

> "The call for integrating academic content into career and technical education is getting stronger."

Challenges to Implementing the Standards

However, there are some very real challenges to the Standards for Mathematical Content. For many CTE instructors trying to implement them, there are two significant challenges. One challenge is simply the size of the CCSS for Mathematics document. It is 95 pages long, and while there are only eight standards for mathematical practice (Figure 1), there are 395 mathematical content standards broken down by grade level for K–8 and by five conceptual categories for grades nine through 12.

At the 2013 Building Bridges conference in Missouri, Larae Watkins, co-director of the Missouri Center for Career Education (MCCE), and I sought to alleviate some of this challenge in the presentation, "The Most Common Common Core Math Standards." This presentation was based on work we did back in 2011, where we—along with CTE teachers, academic teachers and officials from the Missouri Department of Education—spent a great deal of time studying the standards. There are 156 Standards for Mathematical Content in the high school portion of the CCSS, and our goal was to develop crosswalks between the CCSS for Mathematical Content and the curricula for CTE programs.

As we worked through the process, we discovered that 25 of the standards appeared frequently, with three of them—N-Q.1, N-Q.2 and N-Q.3—appearing

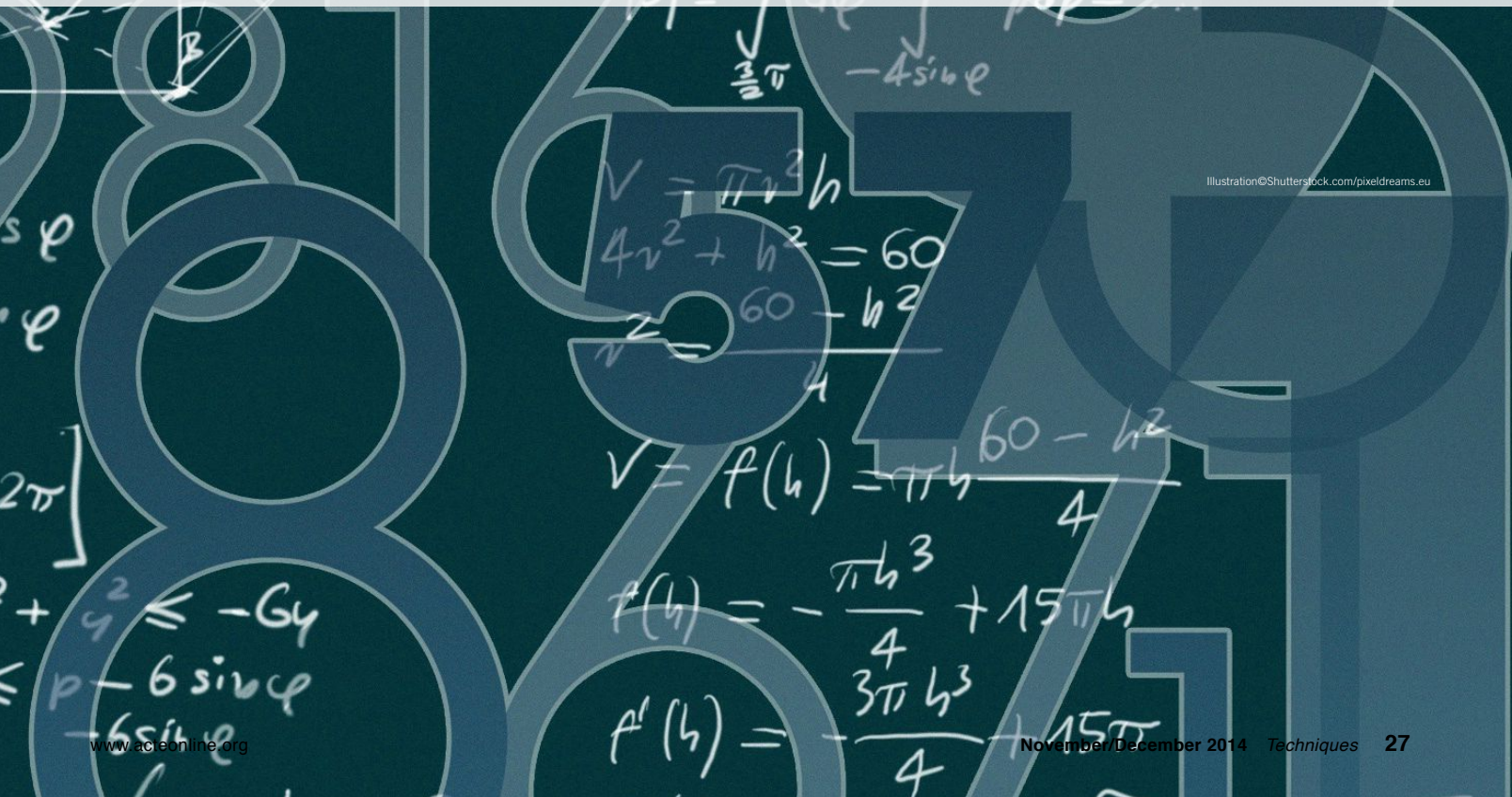
Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning

Figure 1. The Standards for Mathematical Practice

COMMON GROUND: INTEGRATING THE COMMON CORE AND CTE

By David Richner



most often (Figures 2 and 3). This list of 25 standards in Figure 3 enables CTE teachers to start looking for connections from a more manageable list.

The second challenge for many instructors is interpreting the standards for mathematical content. The three standards in Figure 2 may appear overwhelming in the language used. MCCE has a number of resources on the C.O.R.E. portion of its website to address this challenge, including a math glossary and the C.O.R.E. Planning Tool (www.missouricareereducation.org/doc/core/PlanningToolForm.pdf), a spreadsheet we created that, among other things, allows a CTE instructor to simply indicate when he or she knows any math is in the unit. It's at this point that collaboration with a certified math instructor is extremely helpful! Not only is this encouraged by MCCE and facilitated by its resources, but it is a key component of the research study done by the National Research Center for Career and Technical Education and its Math-in-CTE program.[4] The Math-in-CTE model can be seen in Figure 4.

Quantities★ N-Q

Reason quantitatively and use units to solve problems.

1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
2. Define appropriate quantities for the purpose of descriptive modeling.
3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Notes:
*Taken from p. 60 of the C*ommon Core Standards for Mathematics *at www.corestandards.org/wp-content/uploads/Math_Standards.pdf*

The ★ on "Quantities" indicates this cluster of standards should incorporate modeling (See standard 4 of the Standards for Mathematical Practice (Figure 1).

Figure 2. The Domain, Cluster and Standards for Mathematical Content in the High School Number and Quantity Conceptual Category of the CCSS for Mathematics

Addressing Challenges for High School Math Teachers

There is also a challenge for math teachers, which should encourage them to collaborate with CTE teachers. Due to the thrust toward career and life readiness in the CCSS, many proposed assessment questions contain a CTE context. There are two multi-state assessment consortia developing tests and assessment systems that correlate with the standards—Smarter Balanced Assessment Consortium (SBAC) and the Partnership for Assessment of Readiness for College and Careers (PARCC).

Both consortia have made available sample questions and activities that contain real-life application performance tasks. For instance, SBAC has in its digital library a scenario where students will decide on what type of air conditioner to purchase based on density and volume concepts, which is from the Louisiana Department of Education. These tasks may include research, discussion and writing. In the air conditioner problem, for example, students might discuss types of air conditioners, learn about how air conditioners are sized, find prices of air conditioners, and then properly size and price an air conditioner for their classroom. While the complexity of problems and levels of connection to CTE vary considerably, many math teachers could use the content expertise of CTE teachers in a wide range of fields.

In the massive amount of information and question examples available from both these consortia, connections can be found to agriculture, computers, health sciences, automotive technology, business, sports and many more. Furthermore, there is a tremendous use of technology in the testing format itself, with the use of videos and even simple simulations to develop the context.

Integrating Math Into CTE Courses

Imagine entering an Automotive Technology classroom and finding two teachers, two tires and a group of students doing math. What is happening with the two tires? Students are reading the information from the sidewall of each tire, explaining the meaning of this information and calculating the tire sizes. This exercise involves conversions that mathematically incorporate aspects of the three standards for mathematical content shown in Figure 2.[5] (These standards are connected with the dimensional analysis some program instructors may use, and they are the most universally connected to CTE.)

Why are there two teachers? In this instance, there is an Automotive Technology instructor and a math teacher. As mentioned previously, this double-instructor model is becoming a common occurrence at many career centers. Such collaborations, which should play out in deeper, richer activities for the students, will ideally be beneficial for the teachers involved, even if they cannot spend time in the classroom together. Their combined expertise enables students to do more critical thinking in a contextual setting, which really gets at many of the broad goals of the standards.

Let's go back to our two tires. Calculating tire sizes from the information on the sidewall of the tire is only the beginning. Here's an example: Two tires of different sizes are in the classroom. A discussion ensues about which tire travels farther in one full revolution. This can easily be visually illustrated with a piece of tape or other marking placed on the tire and aligned with a long strip of tape on the floor as the

starting point. The tires are then rotated once so the sidewall marking comes back to the floor. This discussion then allows several additional, related mathematical concepts to be presented within this developing context. How many rotations does each tire go through to travel a mile? How many revolutions does each tire cycle through in a minute (rpm) when traveling 20, 40 or 60 miles per hour? If the tires issued on a vehicle are replaced with a different size, what is the effect on the speedometer reading at various speeds? This exercise can be concluded with students developing formulas that allow them to plug in any distance or speed to get the information they need. This is now more synchronized with the type of robust, connected activity the CCSS for Mathematics requires in the "Key Shifts in Mathematics,"[6] found on the Common Core State Standards Initiative's website.

The standards shown in Figure 2 can also be incorporated in Health Science classes, where students calculate various unit conversions or examine relationships between various units of measure and apply dimensional analysis in the process. Several of the standards in Figure 3, such as the numbers and quantities, functions, and geometry, can be integrated in mixture calculations which appear in Health Sciences, Agriculture and Automotive Collision classes.

A Construction Technology program, over the course of its planning and framing units, may calculate areas, volumes and assorted rate and slope values for a construction project, which can include several geometry content standards. A more detailed construction activity requires students to measure the height of a piece of tape placed horizontally on a hallway wall and calculate the values needed to construct a stair stringer. Then they can lay out the stringer on a section of paper towels using a framing square or other appropriate, available tools. If short on such tools, even a file folder and ruler can be used to lay out the 90° angles. These can then be cut out and taped to the wall using the properly adjusted measurements associated with dropping the stringer for the tread thickness.

In collaboration with a math teacher, there are additional opportunities in the study of stair stringer (carriage) and rafter layouts. The math teacher may need some general instruction in the stair design process, but should then be able to incorporate several other math concepts, including the use of trigonometry and similar triangles.[7] A math teacher has many opportunities to find math used in CTE fields and may be surprised by the variety and depth of uses, as well as the mathematically connected concepts, across fields.

CCSS Math Content Commonly Found in CTE

High School

- N-Q.1-3
- A-SSE.1-3
- A-CED.1-4
- A-REI.2
- F-IF.4-5
- F-BF.1
- F-LE.5
- G-GMD.1, 3-4
- G-MG.1-3
- S-ID.7, 9
- S-IC.6
- S-MD.7

*Other math students often need comes from the pre-high school standards

Legend:
N-Q = Numbers and Quantities
A-SSE = Algebra-Seeing Structure in Expressions
A-CED = Algebra-Creating Equations
A-REI.2 = Algebra-Reasoning with Equations and Inequalities
F-IF = Functions-Interpreting Functions
F-BF = Functions-Building Functions
F-LE = Functions-Linear, Quadratic and Exponential Models
G-GMD = Geometry-Geometric Measurement and Dimension
G-MG = Geometry-Modeling with Geometry
S-ID = Statistics-Interpreting Categorical and Quantitative Data
S-IC = Statistics-Making Inferences and Justifying Conclusions
S-MD = Statistics-Using Probability to Make Decisions
Numbers denote standard number

Notes:
On p. 84 of the Common Core State Standards for Mathematics document there is a call to remain fluent in pre-highschool standards. "Indeed some of the highest-priority content for college and career readiness comes from Grades 6–8."

On the CCSS Math main webpage (www.corestandards.org/Math/) is the link for "Standards by Domain" which look at some main math concepts that cut across grades and categories.

Also, look for "Mathematics Appendix A, Designing High School Mathematics Courses Based on the Common Core State Standards," which is an additional resource for planning curriculum.

Figure 3. Mathematical Content Standards Often Found in Connection to CTE (National Governors Association Center for Best Practices, 2010)

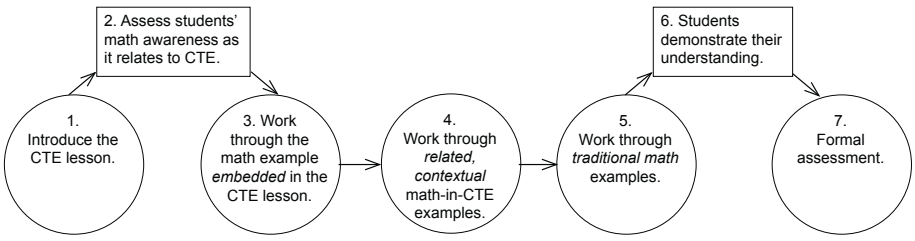


Figure 4. The Math-in-CTE Model: The Seven Elements of a Math-enhanced Lesson (Reprinted with permission from the NRCCTE and is taken from the report, "Rigor and Relevance: A Model of Enhanced Math Learning in Career & Technical Education" (2007)

Resources

An enhanced level of mathematical activity can be incorporated in any program, but it requires a concerted team effort.

MCCE has a number of idea starters for your classroom (www.missouricareereducation.org/for/ccss/) in a handful of the Career Clusters,® including Agriculture, Food and Natural Resources, Health Sciences, and Information Technology, among others, and has places for instructors to share their ideas and resources.

More resources are on the way in other venues! For example, Pat Gillman from State Fair Community College, Nathan Wittmaier from MCCE, and I are starting a video project of some of these math concepts in CTE fields, which will be a resource for CTE and math teachers, and will offer an increase in depth of the math explored in connection with the CTE projects/activities and emphasize the connection to the math standards.[8]

Reaching the Goal

Educator partnerships may take many forms, but the introduction of the CCSS into the educational system, including CTE, necessitates changes in the ways students are taught so that they have the best opportunity to meet these standards. Teachers, therefore, must seek ways to work cooperatively, even outside the bounds of traditional, single-teacher classrooms. Such practices may, in the end, enhance both the learners' and the educators' grasp of their area of training and expertise. Incorporating these academic partnerships with CTE should enhance the education of all students as the Common Core State Standards and other rigor and relevance goals are implemented. Tech

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ENDNOTES

1. Common Core Standards Initiative. (n.d.). *Read the standards.* Retrieved from: www.corestandards.org/read-the-standards/
2. Common Core Standards Initiative. (n.d.). *Common Core State Standards for mathematics.* Retrieved from: www.corestandards.org/wp-content/uploads/Math_Standards.pdf
3. Common Core Standards Initiative. (n.d.). *Common Core State Standards for mathematics.* Retrieved from: www.corestandards.org/wp-content/uploads/Math_Standards.pdf, p. 7.
4. The CTE-math teacher teams were brought together for extended professional development that took place over the course of a school year to learn the process and pedagogy of the Math-in-CTE Model. Retrieved from: www.nrccte.org/resources/studies/math-cte-research-study-building-academic-skills-context-testing-value-enhanced
5. Common Core Standards Initiative. (n.d.). *Common Core State Standards for mathematics.* Retrieved from: www.corestandards.org/wp-content/uploads/Math_Standards.pdf, p. 60.
6. Common Core Standards Initiative. (n.d.). *Key shifts in mathematics.* Retrieved from: www.corestandards.org/other-resources/key-shifts-in-mathematics/
7. See https://www.youtube.com/watch?v=VHVSeI3tLUk or search "Dave Osborne stairs" for more math connection illustrations.
8. Within the resources and new assessments developed for use with the CCSS is a significant reliance on the power of technology. Teachers with abilities to use electronic spreadsheets, surveys, forms and questionnaires can have students calculate values and then provide feedback on their answers based on the initial conditions students are given or create. When developed well, these tools also benefit teacher partnerships toward making the goals on real-life applications and academic testing more complementary than has been the case historically.